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RESPONSE OF PASSERINES TO ABRUPT FOREST-RIVER AND FOREST-POWERLINE EDGES IN MAINE

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ABSTRACT.—The effects of abrupt edges upon passerine richness and density in avian communities were investigated by censusing birds along transects perpendicular to two forest-estuarine river edges and two forest-powerline edges. Density and species richness were not consistently greater near the edges than in the forest interior. Richness within 30 m of powerlines was greater than richness from 60 to 90 m of them, perhaps because there were four species that used both forest and powerline habitats. *Received 25 Jan. 1988, accepted 1 July 1988.*

Forest edges often have greater density and diversity of birds than does adjoining forest (Lay 1938, Johnston 1947), a phenomenon known as the edge effect. The cause of edge effect has been variously explained. Species needing two adjacent ecosystems may join with inhabitants of each ecosystem, resulting in greater density and diversity than occurs in either system alone (Odum 1971). High primary productivity or a large variety of insects at the edge (Hansson 1983) or dense multi-layered foliage or high light intensity (Strelke and Dickson 1980) may be special attributes of edges that attract birds. Edges may act as boundaries of territories and concentrate birds (Anderson et al. 1977). To determine whether the edge effect at forest-water and forest-open land interfaces are similar, and to isolate some of the characteristics of an edge associated with edge effect, we compared patterns of passerine density and species richness at the edges of four oak-pine forest sites in south coastal Maine. Two of the sites were beside powerlines, two beside estuarine rivers. The forests beside estuaries had no riparian vegetation; that is, the upland forest extended to the high-tide level and there was no zone of intermediate vegetation. The terrestrial edges were also abrupt, with a very narrow or no ecotone or zone of intergradation. Thus, the special vegetation of an ecotone would probably not influence bird distribution at these areas.

Study areas.—The areas bordering powerlines, Deer Meadow and Newcastle Ridge, were in Lincoln County, and two areas beside estuarine rivers, Robinhood Cove and Holt Forest, were in Sagadahoc County. Robinhood Cove and Newcastle Ridge were 28.8 ha in size. Deer Meadow had an area of 11.5 ha, and the part of the Holt Forest that was studied

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extended for 14.4 ha. The periphery of each area was at least 200 m from any other edge. Vegetation at all areas was composed primarily of red oak (*Quercus rubra*) and white pine (*Pinus strobus*). Hemlock (*Tsuga canadensis*), balsam fir (*Abies balsamia*), and white birch (*Betula papyrifera*) were common. All study areas except Holt Forest contained parts of a red maple (*Acer rubrum*) swamp. Several juniper patches were located from about 180 to 300 m from the edge at Robinhood Cove. The Robinhood Cove study area on Georgetown Island ended abruptly at a rocky shoreline. The Holt Forest was on Arrowsic Island; most of the shore was rocky, but part of it was a tidal flat with some salt marsh vegetation. Newcastle Ridge and Deer Meadow were along a powerline established between 1965 and 1966. The powerline corridor was 60-m wide and was dominated by grasses and low shrubs such as raspberry (*Rubus* spp.) and blueberry (*Vaccinium angustifolium*). The right-of-way is maintained with a 4-year periodic application of herbicides. The most recent application was in 1985. Newcastle Ridge is south of the powerline; Deer Meadow is about 1 km east of Newcastle Ridge, on the north side of the powerline. Selective cutting had been done in past years at both sites, and damage from gypsy moths was also apparent.

METHODS

Parallel transects were established from the powerline or river edge to 360 m into the forest interior, with flagging dividing it into 30 m segments. There were eight transects each at Newcastle Ridge and Robinhood Cove and four each at Deer Meadow and Holt Forest. Transects were 100 m apart and at least 240 m from any other edge; at Deer Meadow, transects were only 80 m apart. Bird densities were censused by line transect sampling (Anderson et al. 1976, Mikol 1980). Six censuses were conducted at each study area in 1984 and again in 1985. Study areas were censused sequentially from 28 May through 4 July in 1984 and from 26 May to 5 July in 1985. We began censusing within a half hour of sunrise and ended before 0945 hours. We alternately began each census at the first or last transect of a study area. Censuses were not conducted during rain, strong wind, or moderate to dense fog. During each census, we recorded species, sex, perpendicular distance from the transect, and the 30-m segment for each bird that was observed. Pairs and flocks of birds were recorded as a unit or group, although the number of individuals was recorded and later used to correct estimates of density (Burnham et al. 1981). Densities for passerines were estimated using a modification of Emlen's technique (Ramsey and Scott 1979).

Several passerine species were grouped as "edge" or "interior" birds. A species was included in the edge group if more than 60% of its sightings were within 60 m of one study area's edge during both years of the study. For species with few observations, this trend also had to occur within another study area for a year. If fewer than 5% of the sightings for a species were within 60 m of an edge at one study area for both years, it was classified as an "interior bird."

Multiple linear regressions (Dixon 1983) were used to determine whether passerine density or passerine richness was related to the distance from the edge. Ramsey and Scott's (1979)

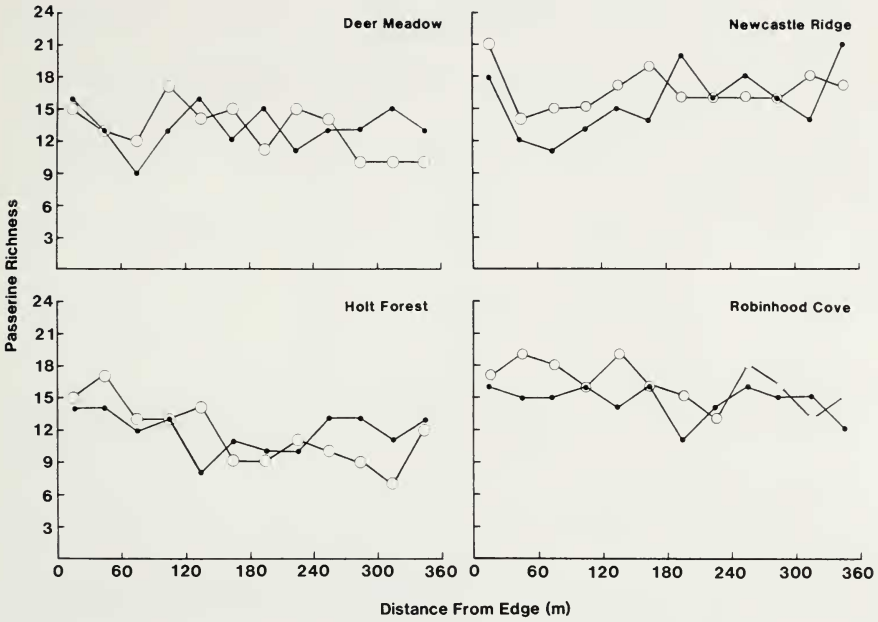

FIG. 1. Richness of passerines per 30-m segment at different distances from the edge. Closed circles are from 1984 censuses; open circles denote 1985 results of powerlines (upper graphs) and rivers (lower graphs). Points are located at segment midpoint.

modification of Emlen's technique was used to determine the density of passerines at various intervals from each edge. These intervals were 30-m long at the two larger study areas, but 60-m segments were used at Deer Meadow and Holt Forest to increase sample size. The density of passerines in the interval nearest the edge was compared to the density of the rest of the study area according to Chebyshev's theorem (Lapin 1980). Richness from 0 to 30 m from an edge was combined for each edge type and compared to richness at 60 to 90 m by a t-test.

RESULTS

The study areas beside powerlines had more passerine species within 30 m of the powerline than within 60 to 90 m of it ($P < 0.05$), but study areas beside rivers did not show this abrupt change in richness ($P > 0.05$) (Fig. 1). Overall, multiple regressions indicated a decline in species richness as distance from edge increased for three of eight surveys in 1985: Holt Forest ($P = 0.0049$), Robinhood Cove ($P = 0.0357$), and Deer Meadow ($P = 0.0414$).

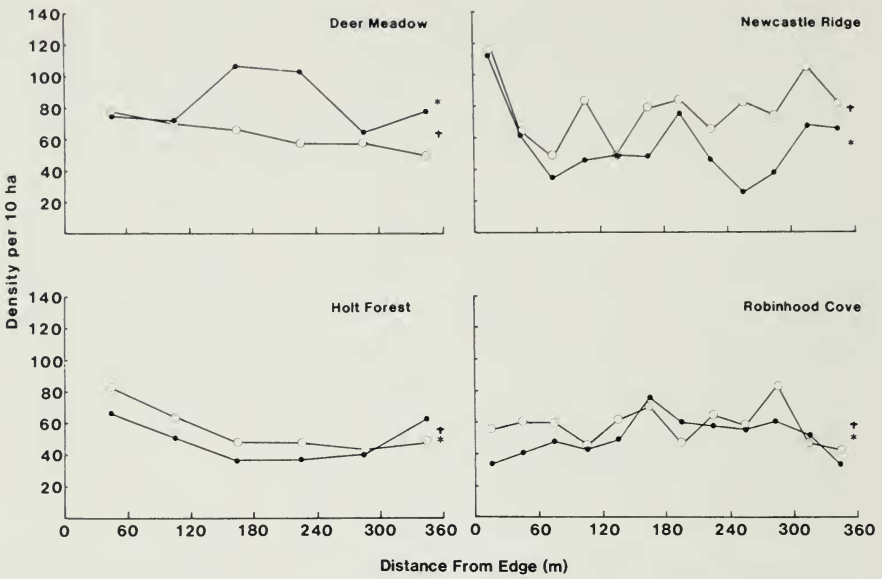

FIG. 2. Density of passerines per 10 ha at different distances from the edge. Closed circles denote 1984 results, open circles, 1985 results. Points are located at segment midpoints. Asterisks are 1984 mean densities, crosses are for 1985 means.

Density of passerines showed no consistent relation to distance from an edge (Fig. 2) and passerine density near an edge was different from the average density of all other segments only at Holt Forest in 1985 ($P < 0.05$) (Table 1). Multiple linear regressions indicated that density decreased with increasing distance from the edge at Holt Forest in 1985 ($P = 0.0425$) and at Deer Meadow in 1985 ($P = 0.0003$).

Chestnut-sided Warbler (*Dendroica pensylvanica*), Magnolia Warbler (*D. magnolia*), Common Yellowthroat (*Geothlypis trichas*), Indigo Bunting (*Passerina cyanea*), Rufous-sided Towhee (*Pipilo erythrophthalmus*), Song Sparrow (*Melospiza melodia*), and Great Crested Flycatcher (*Myiarchus crinitus*) were classified as edge birds. Interior birds were comprised of Canada Warbler (*Wilsonia canadensis*), Northern Parula (*Parula americana*), Wood Thrush (*Hylocichla mustelina*), and Eastern Wood-Pewee (*Contopus virens*). Thirty-seven species could not be classified as either edge or interior species. Of the edge species, Chestnut-sided Warbler, Magnolia Warbler, and Indigo Bunting occurred only in the forests bordered by a powerline; Song Sparrows occurred only beside the river edges. Great Crested Flycatchers and Rufous-sided Towhees occupied both pow-

TABLE 1

DENSITY[a] OF PASSERINES IN THE SEGMENT NEAREST AN EDGE COMPARED TO MEAN DENSITY IN THE REMAINDER OF THE STUDY AREA

Study area	Year	Edge density	Mean density[b] interior	*P*[c]
Holt Forest	1984	66.4	45.7 (11.4)	0.305
	1985	83.1	49.8 (7.4)	0.049
Robinhood Cove	1984	34.1	52.6 (11.4)	0.381
	1985	55.9	57.6 (12.0)	1
Deer Meadow	1984	75.5	84.7 (18.9)	1
	1985	77.1	60.1 (8.8)	0.268
Newcastle Ridge	1984	111.1	50.9 (15.4)	0.065
	1985	115.6	74.2 (16.4)	0.157

[a] Densities are per 10 ha. Holt Forest and Deer Meadow have 60-m segments; Newcastle Ridge and Robinhood Cove have 30-m segments.
[b] (SD).
[c] Probability of no difference as tested by Chebyshev's inequality.

erline and estuarine forests. The flycatchers acted as edge birds only beside one river, and towhees, only beside powerlines.

DISCUSSION

Passerines showed no consistent edge effect: richness and total density were not always greater near the edge than in the forest interior. Richness within 30 m of powerlines was greater than richness from 60 to 90 m of them, but this pattern did not occur beside rivers. Also, this trend did not extend farther into the forest: richness declined as distance from the edge increased in only 3 of 8 surveys, two at river sites and one at a powerline site. Different edge species occurred at the powerline and river edges; only the Common Yellowthroat was found at both edge types. Because forest vegetation was similar among study areas, the difference in bird species composition was likely due either to microclimate differences or to the presence of a brushy ecosystem beside one edge type and not the other. The Indigo Bunting (Conner et al. 1983), Chestnut-sided Warbler (Collins 1983), Magnolia Warbler (Collins 1983), and Rufous-sided Towhee (Bent 1968) all need shrubs or brush, and all were found near the powerline edges but not near the river. These species were probably using both the powerline and forest as habitat.

Several studies of abrupt edges have shown that greater densities of birds (McElveen 1979, Strelke and Dickson 1980, Hansson 1983) may occur at the edge than in forest interior. In contrast, Kroodsma (1982) found that in two of three surveys, density was no greater at an abrupt

powerline edge than in the forest interior. Our findings concur with his results. The study areas where an edge effect occurred (McElveen 1979, Strelke and Dickson 1980, Hansson 1983) were all beside clearcuts, and the edges were unmaintained and younger than the powerline edges; such edges would change with time (Ranney et al. 1981). In contrast, the powerline edges in both studies were maintained every four years, and the river edges were essentially permanent. Balda (1975) suggested that permanent ecotones may not support as diverse a bird species community as temporary ecotones and perhaps density is also not enhanced in permanent edges.

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